WE CLAIM:

1. The SUVR method for reducing or substantially eliminating oxides of nitrogen (NO_x) from an effluent gas stream between 300-800°K and that contains oxygen gas (O_2) by reacting NO_x with the amidogen radical (NH_2*) to form to harmless nitrogen gas (N_2) and water vapor (H_2O), the method including the steps:

a) providing a source of ultraviolet radiation with sufficient output between 180 nm and 220 nm and preferably in the range of 193 to 206 nm associated with a duct containing the effluent stream, or streams,

b) mixing ammonia or an ammonia-based reagent with said stream, upstream of said ultraviolet radiation source so that the variance is within +15%/-5% of stoichiometric concentration,

c) causing said ultraviolet radiation source to irradiate the stream with effective wavelength band and intensity flux sufficient to dissociate the ammonia molecules (NH_3) to the amidogen radicals (NH_2*) and to excite and dissociate NO_x molecules to promote the ($NO + NH_2$*) to ($N_2 + H_2O$) reduction reaction.

2. The method of claim 1 including controlling the rate of ammonia or ammonia based reagent added to said stream including measuring upstream NO_x and downstream NO_x and/or NH_3 slip.

3. The method of claim 1 including effecting dissociation of virtually all of the ammonia and producing a purified effluent stream that contains an insignificant amount of residual ammonia.

4. The method of claim 1 including controlling the volumetric flux of UV radiation in response to measuring/sampling upstream NO_x and downstream NO_x and NH_3 slip and in response to measuring actual UV flux in the reaction zone.

5. The method of claim 1 including providing a venturi mixer operating to uniformly mix the ammonia reagent into the effluent gas stream, the differential pressure across the venturi mixer and differential pressure across mixing nozzles and temperature being used to estimate mass rates to auto correct for rapid changes in load, or optionally monitoring measured mass rates of the effluent gas and ammonia reagent for changes in load.

6. The method of claim 1 including providing an excimer or ion laser with rasterization of effluent gas with beam or beams in the UV spectrum between 172 nm and 220 nm, and optionally using an ArF laser at 193 nm output as an optimal excimer laser for the SUVR process, with optional laser output in visible or near infrared spectrum, frequency doublers or quadruples being used to reduce the wavelength to the useful UV spectrum.

7. The method of claim 1 including employing a two stage system for reducing NO_x levels by factor greater than 50, the two stage system allowing enough residence time between stages so that the valid measurement of un-reacted NO_x and NH_3 can be measured to check for stoichiometric concentration of NH_3, the two stage system optionally characterized by two ultraviolet element reaction zones; a laser rasterized zone and an ultraviolet element zone; an amidogen radical injection zone and an ultraviolet element zone; an amidogen radical injection zone and a laser rasterized zone; or two laser rasterized zones.

8. The method of claim 1 including

employing a two stage system for reducing NO_x levels in a hot exhaust stream by injecting an aqueous base solution to disperse an ammonia reagent, and cooling the effluent gas to below 500 °K, the aqueous solution injection optionally including lances or venturi plate, the dilution of aqueous phase reagent being controlled by measuring the temperature and differential pressure across the mixing plate or the actual mass flow rate.

9. The method of claim 1 including

employing a two stage retrofit or technology transition system for reducing NOx levels, where the first stage is a conventional NSCR, SCR or SHR system and the second stage is a SUVR system with ultraviolet elements acting to polish the ammonia and NO_x slip to below 1 ppm.

10. The method of claim 1 wherein the

radiation source is provided in the form of elongated tubular emitters spaced apart and located in an orientation with respect to the velocity vector of the effluent stream, whereby the pollutant gases flowing around the emitters are treated uniformly and completely.

11. The method of claim 1 including the

employing chevrons or other particle impact shields to arrest erosion or darkening of a tubular or planer radiation emitter surface.

12. The method of claim 1 including

employing electrostatic force to reduce or prevent particle buildup on tubular or planer emitter surfaces and to encourage particle collection on an impact shield, the electrostatic

force being created by a high frequency, high voltage source connected to the emitter surface while an impact shield is used as the ground plane.

13. The method of claim 12 including installing of said tubular or planer radiation emitters in wet or dry precipitators to augment particle collection by ultraviolet light enhanced particle charging and simultaneous reduction of NO_X emissions.

14. The method of claim 1 wherein a radiation source is provided in the form of one or more LED arrays producing the effective wavelength and intensity of radiation.

15. The method of claim 1 employed to eliminate residual ammonia in an effluent or process stream or to prevent the formation of detached ammonium chloride plumes in combustion processes that release ammonia and chloride compounds in the effluent gas stream, whereby the ammonia in the effluent gas stream is destroyed.

16. The method of claim 1 wherein the tubular emitters are located around the perimeter of a duct passing said flow stream.

17. The method of claim 1 wherein an amidogen generator is provided using as an ultraviolet source, a laser with spectrum out put between 172 nm and 220 nm, or a corona discharge using a metal electrode and a dielectric

surface or two dielectric surfaces, or a packed dielectric bed discharge, or an electron beam.

18. The method of controlling the wavelength and the volumetric flux intensity of an SUVR process to reduce or substantially eliminate unburned hydrocarbons or volatile organic compounds, VOC's, ($C_xH_yO_z$) including carbon monoxide (CO) and halogenated VOC's ($C_xH_y(F,Cl,,Br,I)_z$) from effluent gas streams that contain oxygen gas (O_2) and water vapor (H_2O) by reacting these species with oxygen based radicals (O^*, O_2^-, HO_2^*, OH^*) to form to carbon dioxide (CO_2) and water vapor (H_2O), the method including:

a) providing a source of ultraviolet radiation with sufficient output between 172 nm and 220 nm and preferably in the range of 179 nm to 190 nm associated with a duct containing the effluent stream, or streams,

b) providing a source of electrons with energies of 4 eV or greater, derived from a corona discharge or electron beam,

c) causing said ultraviolet radiation, or electron source, to achieve intensity flux sufficient to dissociate the water molecule (H_2O) and the oxygen molecule (O_2) to oxygen based radicals (O^*, O_2^-, HO_2^*, OH^*) and to excite VOC molecules ($C_xH_yO_z$) to expedite the oxidation reaction and dissociate halogenated VOC's (F,Cl,,Br,I) to form halogen acids.

19. The method of claim 18 including removing halogen acids (HF, HCl, HBr, or HI) and sulfuric acid (H_2SO_4) generated in the oxidation process down stream by converting them to an ammonium salt or salts, the method using wet or dry electrostatic precipitation, or by absorbing the halogen acid in an aqueous solution containing a base metal (Na, Ca, Mg, K, etc.) or by absorption on a filter impregnated with activated carbon and/or calcium or magnesium oxide.

20. The method of claim 19 that includes

doping of effluent gas with a sulfur based compound such as a mercaptan, to create an ammonium sulfate aerosol to agglomerate ammonium halogen salts in the dry electrostatic precipitator, and optionally using the mercaptan as a real time surrogate tracer for monitoring destruction of halogenated VOC's when a mid-infrared spectrometer analysis is not available.

21. The method of claim 18 including

operating a two stage system for reducing high levels of VOC's by factor greater than 100, wherein the first stage includes injection of ozone, or ozonated air, or oxygen based radicals (O*, O_2^-, HO_2*, OH*) from a generator using water vapor and an oxygen source, and the second stage uses ultraviolet radiation or electron source to achieve intensity flux to dissociate the water molecules (H_2O) and the residual oxygen molecules (O_2) to oxygen based radicals (O*, O_2^-, HO_2*, OH*) and to excite remaining VOC molecules ($C_xH_yO_z$) to expedite the oxidation reaction and dissociate halogenated VOC's (F,Cl,,Br,I) to form halogen acids.

22. The method of claim 18 including

controlling the volumetric flux of UV radiation or electron bombardment by measuring/sampling upstream VOC's and downstream oxidation products with mid-infrared spectroscopy or full range UV-B to near infrared spectroscopy and by measuring actual UV flux in the reaction zone and oxygen and/or water vapor content.

23. The method of claim 21 including

controlling the volumetric concentration of injected oxygen based radicals by measuring/sampling upstream VOC's and downstream oxidation products with mid-infrared spectroscopy or full range UV-B to near infrared spectroscopy and by measuring second stage UV flux in the reaction zone and oxygen and/or water vapor content.

24. The method of claim 18 wherein the CO or

VOC's are controlled in an initial process stage followed by a NO_x reduction stage that includes the injection of ammonia-based reagent, mixing of the reagent in the effluent gas stream and photo-chemical reduction of NO_X.

25. The method of claim 7 of a two stage

SUVR process whereby the NO_x is controlled and residual ammonia effectively destroyed in an initial process stage followed by a VOC destruction stage to effectively purify the effluent gas stream.

26. The method of claim 18 including

embodying the UV source in a mobile device that is self contained and includes a circulation fan and particulate matter filter, for use in areas where people are present and where the VOC's may present a potential health or safety hazard, and wherein the ultraviolet source optionally has two zones; the first zone for making oxygen based free radicals and ozone, and the second stage for ozone and chlorine gas destruction.

27. The method of claim 26 including

employing a downstream particle filter impregnated with activated carbon and/or calcium oxide to absorb halogen or sulfuric acids.

28. The method of controlling the wavelength and the volumetric flux intensity of an SUVR process to reduce or substantially eliminate ammonia vapors from effluent gas streams between 260-800°K and that contain oxygen gas (O_2) by reacting ammonia NH_3 with hydroxyl radical (OH) to make nitrogen oxide (NO) then reacting NO with the amidogen radical (NH_2*) to form to harmless nitrogen gas (N_2) and water vapor (H_2O), the method including the steps:

a) providing a source of ultraviolet radiation with sufficient output between 180 nm and 220 nm and preferably in the range of 180 to 193 nm associated with a duct containing the effluent stream or streams, to generate hydroxyl radicals to oxidize a portion of the ammonia vapor to nitrogen oxide (NO),

b) thorough mixing of nitrogen oxide with the ammonia contaminated effluent stream, upstream of a next ultraviolet radiation source so the variance is within +15%/-5% of stiochiometric concentration,

c) providing a source of ultraviolet radiation with sufficient output between 180 nm and 220 nm and preferably in the range 193 to 206 nm associated with a duct containing the effluent stream to convert the remaining ammonia to the amidogen radical NH_2*,

d) and causing said ultraviolet radiation source or sources to achieve effective wavelength band and intensity flux sufficient to dissociate the oxygen (O_2) and/or water vapor (H_2O) to react with the ammonia molecule (NH_3) to produce a stiochiometric concentration of nitrogen oxide (NO), then dissociating the remaining ammonia (NH_3) to the amidogen radical (NH_2*) and to excite NO molecules to promote the (NO + NH_2*) to (N_2 + H_2O) reduction reaction.

29. The method of claim 28 including doping

said effluent gas with a sulfur based compound, oxidizing said compound with hydroxyl radicals (OH) to make sulfuric acid, thoroughly mixing the sulfuric acid aerosol with the ammonia contaminated effluent gas to form an ammonium sulfate salt, and wet or dry precipitating the salt aerosol to recover ammonia based salt from the effluent gas while creating product for agriculture, the oxidation process optionally completed with an ultraviolet source in spectrum range of 172 nm to 220 nm, a dielectric barrier discharge, or a scanning electron beam.

30. The method of claim 1 including

providing and operating a gas turbine having an exhaust which defines said effluent gas stream.

31. The method of claim 1 including

providing low pressure mercury vapor lamps operating as said source of ultraviolet radiation.

32. The method of claim 1 including

providing an electrostatic precipitator and operating said source of ultraviolet radiation in series with said precipitator.

33. The method of claim 32 including

subjecting said effluent stream to electron beam processing prior to effluent passage to said precipitator.

34. The method of claim 1 wherein said

source of ultraviolet radiation comprises multiple UV bulbs, which are spaced apart in the path of said effluent stream, and providing chevron shaped elements in said path directly upstream of said bulbs to protect the bulbs from erosion from effluent particles impact.

35. The method of claim 1 wherein said source of ultraviolet radiation comprises one or more UV bulbs, and including the step of flowing particle free gas adjacent the bulb or bulbs as a protection from erosion due to effluent particle impact.

36. The method of claim 1 including converting ammonia to amidogen radical or radically for injection into the effluent stream.

37. The method of claim 36 wherein said converting step is one of the following:

i) operation of an ultraviolet lamp,

ii) operation of LEDs,

iii) dielectric barrier discharge between electrodes,

iv) provision and operation of a dielectric pack bed electrode to provide surface area for absorbed ammonia reactions,

v) provision and operation of an electron beam generator to subject ammonia and water to electron beam processing to create amidogen radical and hydrogen gas.

38. The method of claim 1 including providing lance or nozzle injection of ammonia or urea into the effluent stream.

39. The method of claim 1 including providing and operating venturi apparatus in the path of effluent stream and ammonia flow, for mixing the ammonia with the stream.

40. The method of claim 1 including providing a combustion process stack, wherein said effluent stream flows, during stream irradiation.

41. The method of claim 1 including removing one of the following from the effluent stream prior to said irradiation:

x_1) particulate

x_2) aerosols

x_3) VOCs.

42. A method for reducing or substantially eliminating oxides of nitrogen from a hot effluent gas stream, that includes

a) providing a source of ultraviolet radiation associated with a duct passing said effluent stream,

b) adding an ammonia or amidogen radical based reagent to said stream, upstream of said ultraviolet radiation source,

c) controllably operating said ultraviolet radiation source to irradiate said stream flowing in the duct, to effect reduction or substantial elimination of said oxides of nitrogen by promoting reaction of ammonia with said oxides of nitrogen, to produce N_2 and H_2O flowing in the stream.

43. The method of claim 42 including

controlling the rate of ammonia added to said stream to promote said reduction or substantial elimination of oxides of nitrogen from the stream.

44. The method of claim 43 including

sampling said stream upstream and downstream of the locus of radiation, to determine most efficient rate of ammonia addition to said stream, for conversion of oxides of nitrogen.

45. The method of claim 42 including

effecting thorough mixing of ammonia added into said effluent stream.

46. The method of claim 42 wherein said

operation of the radiation source is effected to control the wavelength of said radiation to dissociate substantially all of the ammonia added into said stream.

47. The method of claim 46 wherein the wavelength or wavelengths of radiation is controlled to between 180 and 280 nanometers.

48. The method of claim 42 wherein the temperature of the irradiated effluent is controlled to be less than 800°K.

49. The method of claim 42 including locating said source in the duct.

50. The method of claim 49 wherein the source is provided in the form of elongated, spaced apart irradiation means extending in the duct, and transversely thereof whereby the effluent stream passes over said spaced apart means.

51. The method of claim 49 wherein the tubular means includes multiple tubes located generally centrally in the duct.

52. The method of claim 42 including providing and operating a combustion process for producing said oxides of nitrogen.

53. The method of claim 42 wherein said effluent stream contains CO, and said controlling step acts to achieve substantially complete oxidation of CO to CO_2, in the duct.

54. The method of claim 42 including operating one of the following processes to produce said effluent gas stream, upstream of said source of ultraviolet radiation:

i) an SNCR process,

ii) an SHR process,

iii) an SCR process.

55. The method of claim 42 including providing at least one additional source of UV emission, downstream in the duct, and a gas mixing plenum or plenums between said sources.

56. The method of claim 55 including the step of independently controlling intensity and wavelength of ultraviolet radiation from said sources.

57. Apparatus for reducing or substantially eliminating oxides of nitrogen from a hot effluent gas stream, that comprises:

a) a duct and a source of ultraviolet radiation associated with said duct passing said effluent stream,

b) means for adding ammonia or amidogen radicals to said stream, upstream of said ultraviolet radiation source, and

c) means for controllably operating said ultraviolet radiation source to irradiate said stream flowing in the duct, to effect reduction or substantial elimination of said oxides of nitrogen by promoting, reaction of ammonia with said oxides of nitrogen, to produce N_2 and H_2O flowing in the stream.

58. The apparatus of claim 57 wherein said source of ultraviolet radiation comprises UV-emitting tubes extending in generally clustered relation.

59. The apparatus of claim 58 wherein said tubes extend in parallel relation to an X-direction; the tubes being spaced apart in a Y-direction; and the duct extending in a Z-direction, where said directions are the X, Y and Z directions in a rectangular co-ordinate system.

60. The apparatus of claim 57 wherein said a), b) and c) comprise a first stage apparatus, and also including a second stage apparatus having a'), b') and c'), corresponding to said a), b) and c).

61. The apparatus of claim 58 wherein said tubes are arrayed in staggered relation presented toward the oncoming stream.

62. The apparatus of claim 58 wherein the duct is locally enlarged to receive said tubes, for enhanced radiation transmission to the stream.

63. The apparatus of claim 1 including dry electrostatic precipitation means in the path of the stream downstream of said radiation source which comprises an electrode beam source.

64. The apparatus of claim 57 wherein said source of amidogen radicals includes steam reforming means.

65. The apparatus of claim 57 wherein UV generator means is located in the duct to provide about 254 nanometers and about 185 nanometers transverse radiation path lengths relative to the duct wall.

66. The apparatus of claim 65 wherein the duct wall provides a reflective inner surface for said about 254 nanometer radiation.

67. The apparatus of claim 57 wherein the source of UV radiation is located in an exhaust stack, and means is provided to effect swirl of the stream, in the stack.

68. The apparatus of claim 57 wherein said radiation source is one of the following types:

i) UV generator,

ii) LED generator,

iii) dielectric barrier between two electrodes,

iv) dielectric pack electrode means,

v) electron beam.

69. A method for reducing or substantially eliminating oxides of nitrogen from a hot effluent gas stream, that includes

a) providing a source of ultraviolet radiation less than about 220 nanometers and associated with a duct passing said effluent stream,

b) adding ammonia to said stream, upstream of said ultraviolet radiation source,

c) controllably operating said ultraviolet radiation source to irradiate said stream flowing in the duct, to effect reduction or substantial elimination of said oxides of nitrogen by promoting reaction of ammonia with said oxides of nitrogen, to produce N_2 and H_2O flowing in the stream.